

**A National Plan for Assisting States, Federal Agencies, and Tribes in
Managing White-Nose Syndrome in Bats**

DRAFT

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I. INTRODUCTION

White-nose syndrome (WNS) is a disease responsible for unprecedented mortality in hibernating bats in the northeastern U.S. This previously unknown disease has spread very rapidly since its discovery in January 2007, and poses a considerable threat to hibernating bats throughout North America. As WNS spreads, the challenges for understanding and managing the disease continue to increase. Given the complexity of the problems facing State and Federal wildlife agencies, a highly coordinated effort is required to effectively manage WNS and conserve species of bats. The plan proposed herein details the elements that are critical to the investigation and management of WNS, identifies key action items to address stated goals, and outlines the role(s) of agencies and entities involved in this continental effort.

Background

White-nose syndrome was first observed in four caves centered roughly 30 km west of Albany, New York, in the winter of 2006/2007. Photographs subsequently emerged of apparently affected bats in nearby Howes Cave, New York, taken during the previous winter, providing the earliest evidence of the disease. Counts at winter colonies of all 6 hibernating bat species in New York revealed that populations had been stable or increasing in recent decades, prior to the arrival of WNS. Whereas the effects of WNS appear to vary between species and winter hibernation sites (“hibernacula”), overall colony losses at the most closely monitored sites have reached 95 percent within 2 to 3 years of initial detection. As of May 2010, WNS has been detected in 6 of the 9 species of hibernating bats that occur in the affected region (Connecticut, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Tennessee, Vermont, Virginia, and West Virginia). Species known to be susceptible to WNS thus far are the little brown bat (*Myotis lucifugus*), Indiana bat (*M. sodalis*), northern long-eared bat (*M. septentrionalis*), eastern small-footed bat (*M. leibii*), tricolored bat (*Perimyotis subflavus*), and big brown bat (*Eptesicus fuscus*). Three additional bat species were found in 2010 that tested positive for the presence of *Geomyces destructans*, the fungus associated with WNS, but not with the infection that is characteristic of the disease. These bats, the gray bat (*M. grisescens*), the cave myotis (*M. velifer*), and the southeastern myotis (*M. austroriparius*), were found in Missouri, Oklahoma, and Virginia, respectively, and their discovery could portend the spread of WNS into new regions of the southeastern and western U.S. in 2011. The disease appears to affect bats most during long torpor bouts characteristic of winter hibernation. Therefore, bat species that use hibernation as a strategy for surviving the winter months, collectively called the “cave bats,” are most notably affected. It is currently not known if WNS is causing mortality in bats that use torpor during winter but do not regularly occur in caves and mines, such as the so-called migratory “tree bats” [for example, silver-haired bats (*Lasionycteris noctivagans*), hoary bats (*Lasiurus cinereus*), eastern red bats (*Lasiurus borealis*)].

The rapid and widespread mortality associated with WNS is unprecedented in hibernating bats. Like other top mammalian predators, such as polar bears, sea otters, and wolves, most of the affected bat species are long lived (~5 to 15 years or more); hibernating bats typically only have one offspring per year, and juvenile mortality is approximately 50 percent in the first winter. Therefore, bat numbers do not fluctuate widely over time, and populations of bats affected by WNS will not be able to recover quickly. Epizootic disease outbreaks such as WNS have not previously been documented in bats.

White-nose syndrome was named for the visible presence of a white fungus around the muzzles, ears, and wing membranes of affected bats. Scientists recently identified a previously unknown species of cold-loving fungus (*G. destructans*) as a consistent pathogen causing skin infection in bats at affected sites. This fungus thrives in low temperatures (5-14°C; 40-55°F) and high levels of humidity (>90 percent), conditions characteristic of bat hibernacula. Pathologic findings thus far indicate that such fungal infections can be detected as early as October, and it is hypothesized that bats affected by WNS arouse from hibernation more frequently, and/or for longer periods than normal, and are prematurely expending the fat reserves they rely on for winter survival. Chronic disturbance of hibernating bats is known to cause high rates of winter mortality through fat loss, and aberrant behaviors associated with WNS may cause bats to consume critical fat reserves too quickly during winter. Aberrant behaviors observed at sites affected by WNS include shifts of large numbers of bats in hibernacula to roosts near the entrances or unusually cold areas; large numbers of bats dispersing during the day from hibernacula, even during mid-winter; a general unresponsiveness to human disturbance; and, on occasion, large numbers of fatalities, either inside the hibernacula, near the entrance, or in the immediate vicinity of the entrance. Although scientific evidence indicates that skin infection by *G. destructans* is a plausible primary cause of mortality associated with WNS, the exact processes by which skin infection leads to death remain undetermined, and it is unclear whether other underlying conditions contribute to susceptibility to fungal infection and/or mortality.

For the purpose of implementing elements of this plan, WNS will be defined as suspect when clinical signs as described above are observed in the field and defined as confirmed with histopathological confirmation of the presence of *G. destructans* within bat tissues.

Ecological Significance

More than half of the 45 species of bats that occur in the U.S. rely on hibernation as a primary strategy for surviving the winter, when insect prey are not available. All four endangered species and subspecies of hibernating bats in the U.S. rely on undisturbed caves or mines for successful hibernation, and are at risk from WNS. Three of these species [Indiana, gray, and Virginia big-eared bat (*Corynorhinus townsendii virginianus*)] are currently within the affected area, and the remaining subspecies [Ozark big-eared bat (*C. t. ingens*)] will likely be at risk soon. Although the potential for WNS to continue to spread is currently unknown, the implications of its undermining the survival strategy of so many bat species are enormous. We are just beginning to appreciate the roles bats play in North American ecosystems, and the impact of WNS on bat populations has the potential to greatly impact ecosystem function. Considerable reductions in predation pressure on insect populations, for example, could lead to increased numbers of insect pests resulting in damage to forests and agriculture, higher loads of environmental pesticides, and/or potential public health risks associated with zoonotic disease or chemical contact.

The Planning Process

Why a National Plan?

The mobility of bats, the rapid spread of WNS, the potential for human-assisted transmission, and the severity of its consequences make it imperative that a national effort on multiple scales be mounted to avoid irreversible losses to bat populations, and associated ecological impacts, throughout North America. It is anticipated that WNS will continue spreading to surrounding

states, and the potential exists for outbreaks due to human activities in states distant to the currently affected area.

State, Federal, and Tribal wildlife management agencies have statutory and regulatory authorities for managing trust wildlife species. In exercising these authorities, agencies must comply with applicable laws. For example, Federal agencies must comply with, among other laws, the National Environmental Policy Act, the Endangered Species Act, and the Federal Cave Resources Protection Act. Some of these laws provide alternative procedures to address emergency situations. A national plan will assist State, Federal, and Tribal agencies in exercising their authorities for managing bats threatened by WNS and in complying with all applicable laws.

There is already a history of State-Federal collaboration in addressing the many challenges posed by WNS, which pre-date the formal requests for assistance made by State agents in the northeastern United States to the U.S. Fish and Wildlife Service and U.S. Geological Survey in the winter of 2007/2008. It is incumbent upon wildlife management agencies to advise non-government organizations and those in the scientific community with appropriate expertise and authorities to assist in mitigating this threat. Further, this collaboration should extend internationally because the risk of WNS extends across borders and these insectivorous bats are a North American resource. A national plan will serve to facilitate this collaboration.

Origin of the Plan

In June 2008, an effort to formalize a coordinated approach for addressing WNS was initiated among DOI, USDA, DOD, and State wildlife management agencies. More recently, a WNS steering committee was formed to ensure that Federal and State agencies coordinate and cooperate in the development and implementation of an effective national response to the disease. This plan is a product of the steering committee; it outlines actions necessary to coordinate Federal and State efforts and identifies actions in support of State, Federal, and Tribal WNS management efforts. While the framework presented in this plan (the base plan) will mostly remain static, the elements of the comprehensive WNS National Plan, incorporating implementation strategies, are intended to be adaptive and will be modified as new information becomes available.

Implementing the Plan

State agencies will largely be responsible for implementing state-level surveillance, population monitoring, and disease management programs. The primary Federal role will be to provide cross-border coordination and assistance with research, surveillance, disease management, diagnostic testing, technology transfer, communications, information dissemination, education, and funding for State WNS programs. Federal land management agencies such as the National Park Service, U.S. Forest Service, and Bureau of Land Management also will provide guidance and policy for addressing WNS in relation to planning and managing Federal lands under their respective jurisdictions. Federal agencies will provide tools and financial assistance, when available, to States and help develop standardized approaches to WNS control and mitigation.

While we have gained considerable knowledge regarding WNS and the potential etiology, there are still large gaps in our understanding. Despite this, general principles of epidemiology,

ecology, and conservation biology will continue to be applied to inform the actions outlined in this plan. When necessary, expert opinion will be used. As our knowledge and understanding of WNS improves, plans will be modified and adapted accordingly to ensure that the best available science is applied to addressing this issue.

The development of coordinated, science-based, response plans tailored individually to meet the WNS-related needs of discrete State, Tribal, and Federal agencies is fundamental to the success of a national plan for managing WNS. Ideally, such plans would consider the needs of all stakeholders and cover multiple jurisdictions, especially when jurisdictions share an affected population. Response plans should follow a standard outline of basic components that include objectives, management tools, management of contaminated environments, results monitoring, restoration plans, and budget. Response plans will form the basis for funding, public responsibility and accountability, and measuring results. Because such coordinated response plans may be difficult to prepare in a short time frame, a process for immediate funding for initial response for newly identified outbreaks should also be made available.

WNS response plans will vary depending upon such factors as length of time the disease has been present, affected species, population density, location, resources, and human dynamics. States and other entities may use different strategies in response to different combinations of these factors. One of the key challenges is to learn as quickly as possible the safety and efficacy of control or disease mitigation strategies. As research knowledge provides new diagnostic, monitoring, and management tools, the challenge will be to continually adapt and improve WNS management strategies.

II. WNS RESPONSE STRATEGY

Human Health Implications

The direct human health risk from WNS is unknown, but appears to be low. Because *G. destructans* only grows at cool temperatures (40-68°F), considerably lower than those of the human body, it is unlikely to cause infection in humans. No human illnesses to date have been associated with contact or exposure to WNS-infected bats or caves. Many WNS-infected bats exhibit unusual behavior and may be found in large numbers in locations not normally inhabited by bats; contact with bats, particularly in these settings, should be avoided since bats are potential sources for other human diseases including rabies, histoplasmosis, and ammonia toxicity. People handling bats or entering their roosts should use safe work practices and personal protective equipment to minimize exposure to infectious or toxic agents. Additional research is necessary to further explore potential human health risks associated with WNS.

General Practices

Our current understanding of the etiology of WNS is incomplete; however, *G. destructans*, the fungus known to cause the skin infection that is the hallmark of WNS, continues to be the common link among infected animals. Even in the face of incomplete information, general epidemiological principles must be used to inform the WNS investigation and response. To cite an historical, human health example, in the mid-1800s, germ theory was not widely accepted and diseases were believed to be caused by miasma, i.e., bad air. Applying modern principles of

epidemiology to a major cholera epidemic in 19th century London, physician John Snow surmised that the source of the outbreak was, in fact, contaminated well water. Even though it would not be known until many years later that cholera is caused by a bacterium (*Vibrio cholerae*), disabling the contaminated well by simply removing the pump handle was enough to end the outbreak. Concerning a much more recent analogue to WNS, it took more than a decade to discover that the cause of the now-global amphibian disease chytridiomycosis was an exotic fungal pathogen. The institution of rigorous widespread precautions during the early years of the chytridiomycosis outbreak might have served to limit the spread of the disease and bought valuable time to institute conservation measures.

All available evidence indicates that WNS is caused by an infectious agent, and therefore can potentially be spread by all known modes of disease transmission, including direct contact, inhalation, ingestion, fomites (inanimate objects), and human or animal vectors. Wildlife diseases such as WNS spread rapidly when there is high prevalence of pathogen(s), efficient chains of transmission, abundant susceptible hosts, and/or environments that allow pathogen persistence without a host. Regardless of the nature of the infectious agent (fungus, bacterium, or virus), universal precautions should be implemented to reduce incidence of disease by both preventing infections and breaking chains of transmission. Therefore, adherence to the following actions/measures is considered to be prudent for combating the spread of WNS through human-assisted means. These recommendations can generally be applied in field situations with reasonable modifications and proper training:

1. Avoiding direct contact with bats, contaminated objects (fomites), and body fluids;
2. Wearing barriers (e.g., gloves, coveralls, etc.) when contact with bats is necessary or expected (single-use items are recommended);
3. Carefully handling, cleaning, and disinfection of potentially contaminated fomites between contact with animals and/or field locations;
4. Observing proper technique during sample collection for genetic or microbiological analyses (e.g. wing punch biopsies).
5. Promoting that prevention of infection requires constant personal surveillance;
6. Maintaining oversight within the research, wildlife management, and caving communities;
7. Adhering to basic hygiene practices that are known to minimize the spread of infectious agents, including use of hot, soapy water for washing hands, clothing, and equipment;
8. Increasing public awareness and education.

Decontamination protocols specific to WNS have been developed and will continue to be revised to incorporate the best available information. All current protocols will be available at the following website: <http://www.fws.gov/WhiteNoseSyndrome>.

Elements of the National Plan

The WNS steering committee identified seven elements to be addressed by the WNS National Plan; each will be administered by a working group responsible for the coordination of activities within that element. The elements are:

- A. Communications and Outreach
- B. Data and Technical Information Management
- C. Diagnostics
- D. Disease Management
- E. Etiology and Epidemiological Research
- F. Disease Surveillance
- G. Conservation and Recovery.

A. Communications and Outreach Working Group: The purpose of this group is to develop and implement an effective plan for communicating information about WNS to partners involved in the WNS investigation, and to the public. The goals and actions outlined in this document provide the basis for a detailed national communications implementation plan.

B. Data and Technical Information Management Working Group: The purpose of this group is to provide a mechanism for making WNS information accessible in a timely fashion to all State and Federal agencies and others involved with the investigation and management of WNS. The primary goal of this group is to disseminate information about WNS by providing access to common scientific and technical information in a partner-based data system; working with States to create data standards that will allow inter-operability with existing WNS data sets; providing researchers and wildlife managers with near real-time access to WNS data and other critical information; and, ultimately, integrating WNS data from State and Federal agencies and others into a more structured national database.

C. Diagnostics Working Group: The purpose of this group is to establish a standard on how laboratories are to conduct and interpret WNS testing so that results are accurate and comparable between laboratories; identify current laboratory capacity for processing WNS samples and project the capacity needed to support effective WNS management programs; provide timely reporting of diagnostic results to resource agencies responsible for management decisions; and support WNS research.

D. Disease Management Working Group: The purpose of this group is to identify a range of alternatives and best practices to prevent the introduction of WNS into new areas, prevent or slow the spread of WNS to WNS-free sites within infected areas, and attain sufficient control of the disease in affected areas so that genetic and regional diversity and the potential for recovery to pre-WNS abundance is maintained; secure the future of bats while avoiding unacceptable risks to other cave-obligate biota and natural systems; and collaborate with public health officials to determine whether a human health threat is associated with WNS and determine a course of action if the WNS agent poses such a threat.

E. Etiology and Epidemiological Research Working Group: The purpose of this group is to identify critical ongoing research needs relating to the origin, transmission, pathogenesis, and impact of WNS on bats and the environment. Research to inform management actions will be a priority; therefore, approaches that recognize the synergy between research and management will be emphasized to maximize the potential to achieve optimal results.

F. Disease Surveillance Working Group: The purpose of this group is to develop standards for WNS surveillance in affected and non-affected areas, and describe best practices and techniques for surveillance strategies.

G. Conservation and Recovery Working Group: The purpose of this group is to develop standards for determining if and when to monitor population numbers of bat species affected by WNS; establish criteria for prioritizing conservation and management activities; and describe best practices and techniques for the recovery of bat populations of greatest conservation concern. Additionally, this group will provide guidance on collection of baseline data for areas still unaffected by WNS, such as conducting a statewide accounting of caves and mines.

III. ACTION PLANS

This section of the plan presents brief treatments for each plan element, providing additional background information and outlining the goals and currently defined actions of each working group. Element sections are divided into two components:

1. Overview
2. Goals and Action Items

A. Communications and Outreach:

A.1. Overview

A rapid and integrated internal and external flow of information is critical to addressing WNS. An organized national program of information dissemination about WNS and affected bat populations will enable those involved in the WNS research, monitoring, surveillance, management and communication effort to work together. Providing the public with information about WNS and its effects builds public support and engagement for the effort. Mechanisms for information flow differ among audiences. The following goals and actions will guide the development of a communications plan that will facilitate information flow to three broad audiences:

1. The WNS investigative community (team) includes Federal and State agencies, Tribes, international government partners, and cooperating non-government research scientists and institutions who are directly involved with WNS research, monitoring, surveillance, management, and communications.
2. Internal audiences include employees of Federal and State agencies, Tribes, and international government partners not directly involved with the WNS investigation.
3. External audiences include non-government research scientists and institutions, non-government organizations, elected officials, decision-makers, news media, and the public.

A.2. Goals and Action Items

Goal 1: Communicate research, monitoring, surveillance, management, and communication activities among the WNS investigative team to facilitate an effective response to WNS.

Actions:

- (1) Finalize an organizational chart to ensure that coordination and flow of communication are clearly defined among the WNS investigative team.
- (2) Designate points of contact for each working group identified in the organizational chart to work with the WNS investigative team on a broad range of communications issues, including when and how proprietary data would be shared among team members.
- (3) Develop a communications toolbox for the WNS investigative team.
- (4) Communicate about activities and distribute products to the WNS investigative team in a timely manner.

Goal 2: Communicate about WNS as an unprecedented wildlife disease event resulting in devastating consequences, spreading at an alarming rate, and with no obvious means of curtailment.

Actions:

- (1) Disseminate information that is responsive to a broad range of frequently asked questions regarding WNS.
- (2) Create, deliver, and update products that can be customized to convey key information about WNS.
- (3) Develop and disseminate communications tools, specific messages and products for internal and external audiences, as needed.

Goal 3: Communicate about the importance of bats to people, ecosystems, biodiversity, and economies.

Actions:

- (1) Disseminate information that is responsive to a broad range of frequently asked questions regarding the importance of bats.
- (2) Create, deliver, and update products that can be customized to convey the key information about the importance of bats.

Goal 4: Communicate about the efforts of the partner agencies and organizations involved in the WNS investigation to control and manage WNS.

Actions:

- (1) Disseminate information that is responsive to a broad range of frequently asked questions about the collaborative effort to control and manage WNS.
- (2) Create, deliver, and update products that can be customized to convey key information about the collaborative effort to control and manage WNS.
- (3) Distribute the recommended practices and procedures to minimize the spread of WNS to all audiences.
- (4) Publish contact information for key WNS investigation team members and State/Federal WNS points of contact.

B. Data and Technical Information Management:

B.1. Overview

Management and dissemination of scientific and technical information is critical to States, Federal agencies, Tribes, and other groups involved in the investigation and management of WNS. Although these entities will collect important data for their own use, there will be significant opportunities for resource sharing as well as assistance for data management and transfer, allowing analyses to be conducted on a continental basis. The creation of uniform standards for data collection and transfer will facilitate research and management of WNS. A unified system will allow economies of scale for the proposed activities to be undertaken at a national level. A strategy to effectively incorporate national data standards with existing local data systems and newly developing systems will enhance efficiency and the effectiveness of data management at multiple scales. Further, data and information from all parties will be securely handled to assure appropriate intellectual property rights and confidentiality, as required by the Federal Cave Resource Protection Act and other authorities.

A secure, Internet-based WNS database will be established to effectively accomplish the efforts outlined in this plan. The WNS database(s) will be designed to provide timely access to biological data and geospatial information specific to the investigation and monitoring of WNS. Planning for the implementation of an initial stage of such a database, with focus on cataloging all available bat specimens, is currently underway with the U.S. Geological Survey Fort Collins Science Center. This database will be modified as needed and when resources are available. The majority of data to be incorporated in the WNS database will be provided by State agency biologists and diagnostic laboratories, with additional information coming from Federal and private/academic partners. The database is intended to explicitly support researchers and managers in addressing WNS data needs, and will allow State and Federal agencies, Tribes, and the public to obtain near real-time data on WNS.

B.2. Goals and Action Items

Goal 1: Provide a database system that can be used by all State, Federal, and Tribal agencies, and serve as a central repository for nationwide analyses and specific projects.

Actions:

- (1) Establish or utilize an existing robust database that can accommodate test results as well as monitoring and surveillance data from State, Federal, and Tribal agencies.
- (2) Develop a data import system to allow State and Federal agencies to enter their current and archival data.
- (3) Develop data collection and management standards in cooperation with State and Federal agencies.
- (4) Develop a certification and quality control system.
- (5) Provide States with a system for tracking WNS samples from collection through laboratory testing.
- (6) Create data-sharing agreements that will allow inter-operability with existing WNS data and among stakeholders, while providing confidentiality of data to data providers as needed.

Goal 2: Integrate WNS data from State and Federal agencies, Tribal and land managers, and other sources into a centralized system.

Actions:

- (1) Conduct a thorough literature review focusing on WNS.
- (2) Assemble information on biology and management of bats and other wildlife species at risk for developing WNS.
- (3) Collect and assemble State, Federal, and other pertinent data.
- (4) Create a Web-based system that will integrate information collected above.
- (5) Catalog and provide Internet links to WNS information resources maintained by Federal, State, and non-government organizations, including scientific libraries.

C. Diagnostics:

C.1. Overview

Accurate, reliable diagnosis of the presence of *G. destructans* and WNS in bats is a foundation for sound, effective disease management decisions by resource agencies. This requires laboratory capacity sufficient to run a meaningful number of standardized assays relative to the sampled population, in a useful timeframe. Primary diagnostic priorities include detecting WNS in new species, new states, and at biologically significant sites that may harbor threatened or endangered bat species or experience significant human visitation. Secondary diagnostic priorities include supporting research and surveillance at previously confirmed WNS positive locations. Group membership should consist of representatives from Federal, State, academic, and/or private laboratories with a minimum of BSL-2 (biosafety level) status demonstrating a willingness to test samples for WNS following established methods provided by the WNS foundational laboratories.

C.2. Goals and Action Items

Goal 1: Develop consensus standards for WNS testing and interpretation.

Action:

Make WNS diagnostic assays available through peer-reviewed publications, protocol summaries, workshops/conferences, and on-site training. This information would be available internationally. Communication among participating labs assures consistent interpretation and diagnoses.

Goal 2: Establish sufficient laboratory testing capacity.

Actions:

- (1) Assess laboratories currently involved in WNS diagnostics for sample processing capacity by the various assay methods (histology, PCR, fungal culture, light microscopy).
- (2) Survey resource agencies for their projected short-term and long-term WNS diagnostic needs.
- (3) Assist agencies in identifying suitable diagnostic laboratories to help meet their disease management needs.
- (4) Assess funding requirements based on the projected diagnostic needs of resource agencies.

Goal 3: Assure quality of sample submissions and comparable results among participating diagnostic laboratories.

Actions:

- (1) Provide training and/or descriptions of ideal sample quality and storage requirements needed for the various WNS assays to resource agencies for distribution to field biologists to ensure suitable sample submissions for diagnostic evaluation.
- (2) Provide case definitions for suspect, presumptive, and confirmed cases of WNS.

Goal 4: Provide timely reporting of WNS testing results to resource management agencies.

Action:

Work with the Scientific and Technical Information Group to develop a secure, centralized diagnostic sample database for future submission status tracking that would be accessible by all contributing agencies for data sharing in a timely manner.

Goal 5: Support WNS research such as epidemiology, treatment/management options, improved diagnostic assay development, etc.

Actions:

- (1) Critically review current knowledge of WNS diagnosis to identify knowledge gaps and research needs.
- (2) Prioritize diagnostic research needs to fill identified knowledge gaps and determine funding requirements.
- (3) Help coordinate laboratory assistance with State- and federally funded WNS research projects requiring sample testing, and ensure that sufficient funding is allocated to support participating laboratories beyond their primary diagnostic priorities.

D. Disease Management:

D.1. Overview

Disease management is composed of three complementary goals: to identify and implement science-based management actions to slow the expansion of WNS in order to delay, for as long as possible, the impacts of the disease reaching unaffected regions of the continent; develop and employ solutions to the disease that will ensure the perpetuation of susceptible bat species, and that will provide the best opportunities for their recovery to pre-WNS numbers in affected regions; and ensure that implemented actions will not be detrimental to bat populations or have unacceptable effects on the ecosystems in which they are found. This work is in its infancy and most of the questions critical to its success have not yet been resolved. There are, as yet, no proven applications that address any of the challenges presented below, and it is unclear whether the objectives detailed below are obtainable. This group will assist State, Federal, and Tribal agencies in determining the goals of management actions taken and the most feasible management tools that can be applied.

Monitoring the effectiveness of management actions will be critical to achieving the goals outlined below. Successful coordination and monitoring of all management actions will

maximize our potential to learn from them and allow managers to employ adaptive management principles to refine research and management priorities. It will be important to develop and/or maintain the necessary capacity within State agencies to support the implementation of these disease management objectives.

D.2. Goals and Action Items

Goal 1: Critically review current knowledge of WNS disease management to identify knowledge gaps and research needs.

Actions:

- (1) Solicit expert review of previous and current research projects and identify knowledge gaps.
- (2) Identify priority research questions and capacity not currently being addressed in the investigation of WNS, including human dimensions.
- (3) Identify high-priority field activities needed to support research priorities.

Goal 2: Reduce the risk of WNS transmission by humans to acceptable levels.

Actions:

- (1) Define “acceptable level.”
- (2) Identify the mechanisms for WNS transmission by humans to environment to bats.
- (3) Provide guidance on regulation or restriction of human actions that are likely to pose a risk for spreading WNS.
 - (a) Develop standards for restricting use of potentially contaminated gear (both caving and bat research) at unaffected sites or regions.
 - (b) Manage cave access to minimize transmission risk.
 - (c) Develop operating guidelines for commercial caves.
 - (d) Modify mist netting/harp trapping protocol/techniques.
- (4) Develop and implement decontamination/disinfection protocols to guard against human-assisted transmission of WNS to new sites or animals.

Goal 3: Reduce inter-/intra-specific transmission.

Actions:

- (1) Conduct and/or support research on bat-to-bat transmission of WNS.
 - (a) Determine effectiveness of removal of infected and surrounding individuals.
 - (b) Identify prevalence/distribution of infected animals within hibernacula/clusters.
 - (c) Develop techniques for identifying infected animals (photo/thermography).

Goal 4: Reduce environmental transmission.

Actions:

- (1) Conduct and/or support research of WNS transmission from environment-to-bat.
- (2) Develop environmental decontamination techniques.

Goal 5: Eliminate *G. destructans* from infected individuals.

Actions:

- (1) Identify means of *G. destructans* control that are effective and safe for the bats.
 - (a) Identify chemical control treatments for *G. destructans*.

- (b) Identify biological control treatments for *G. destructans*.
- (c) Identify effective environmental manipulations to reduce or eliminate *G. destructans* from affected bats or sites.
- (d) Identify effective bat exclusion/inclusion of infected sites/uninfected sites.
- (2) Reduce disturbance-related mortality associated with disease management activities.

Goal 6: Limit adverse ecological impacts of management actions to acceptable limits.

Actions:

- (1) Research the need for, conduct, and/or support human dimensions research to define acceptable limits for all ecological impacts.
- (2) Monitor management action outcomes and use adaptive management iterations to improve results, in light of potential ecosystem impacts.

E. Etiology and Epidemiological Research

E.1. Overview

Although State, Federal, academic, and non-government organization researchers have worked collaboratively to increase understanding of WNS since its discovery, there are significant knowledge gaps regarding the fundamental dynamics and ecology of this disease. These gaps impede the development of plans to control and mitigate the disease, because effective management requires an understanding of the interactions among the disease, its host(s), and the environment. This section identifies priority research areas in which progress must be made in order to better understand and respond to the threat of WNS. Key to managing this disease will be the guiding principle that research must primarily address management needs, and that basic research results should be applied to adaptive management decisions.

Research is still needed on relevant aspects of bat ecology and behavior, diagnostic methods, etiology, pathology, epidemiology of the disease, presence and persistence of the causative agent in the environment, and risks posed to other species. This research will be conducted through partnerships among academic entities, non-government organizations, and State and Federal agencies. New information may shift priorities and reveal new areas of investigation. Therefore, an effective process for coordinating research is also required.

E.2. Goals and Action Items

Goal 1: Critically review current knowledge of epidemiology and ecology of WNS to identify knowledge gaps and research needs.

Actions:

- (1) Solicit expert review of previous and current research projects and identify knowledge gaps.
- (2) Identify priority research questions and capacity not currently being addressed in the investigation of WNS.
- (3) Identify high-priority field activities needed to support research priorities.

Goal 2: Establish disease etiology.

Actions:

- (1) Investigate the role of *G. destructans* as the likely primary causal agent of WNS, and increase our understanding of other potential contributing factors.
- (2) Investigate the origins and evolution of *G. destructans*.
- (3) Continue considering evidence for other potential predisposing and/or causative agents for the suite of WNS signs observed in bats.

Goal 3: Enhance understanding of WNS pathogenesis.

Actions:

- (1) Investigate the life cycle of *G. destructans*, including optimum environmental growth/viability conditions.
- (2) Identify the mechanisms of transmission and infection of *G. destructans*.
- (3) Investigate species differences in pathogenesis and susceptibility.
- (4) Investigate whether other animal taxa are associated with WNS epidemiology.

Goal 4: Understand interactions of pathogen, host ecology, and environment.

Actions:

- (1) Obtain basic epidemiological information (e.g., distribution, prevalence, incidence, case-fatality rates).
- (2) Investigate critical control points in WNS dynamics.
- (3) Collect baseline information in unaffected States.
- (4) Continue long-term monitoring efforts in affected States to identify change over time.
- (5) Design and implement studies to identify disease model parameters, including transmission routes and rates.
- (6) Identify and employ appropriate disease models to evaluate and predict its spread and impact.

Goal 5: Evaluate the ecological consequences of WNS.

Action:

Assess the ecological impacts that result from the dramatic loss of insectivorous bat populations, with an emphasis on impacts to forestry, agriculture, public health, and cave ecosystems.

F. Disease Surveillance:

F.1. Overview

Individual States will likely have different priorities and capabilities due to their geographic location, the bat species present, land ownership, and the influence of other local factors; however, the coordination of agency disease surveillance efforts will be necessary to effectively combat WNS. These efforts will focus on the detection of WNS in bats and their associated habitats. The overarching goal of this group is to provide a framework for consistent, coordinated WNS surveillance, focusing on early detection of the expansion of WNS or newly established epicenters and providing data on the progression of WNS within an affected hibernating colony. Given the critical role that States will play in WNS surveillance, there is a need to ensure that State agencies have the capacity to implement a surveillance plan.

F.2. Goals and Action Items

Goal: Create a coordinated disease surveillance program nationwide that identifies and minimizes disturbance to bats and potential transmission risks while still enhancing early detection.

Actions:

- (1) Develop and provide recommendations for coordinated disease surveillance.
 - (a) In bat populations with confirmed infection, surveillance should detect changes in prevalence and monitor management actions.
 - (b) In bat populations without confirmed infection, surveillance should provide early detection of new WNS foci.
- (2) Identify effective surveillance strategies and assist with implementation.
- (3) Integrate surveillance efforts with elements of other elements of the WNS National Plan.

G. Conservation and Recovery (of Affected Bat Species):

G.1. Overview

Populations of several species of bats are declining because of WNS. Because species affected by WNS range across State and international boundaries, conservation and recovery efforts need to be closely coordinated to be effective.

Monitoring WNS-affected bat populations is necessary to determine which species may be most at risk of local extirpations and extinction due to WNS, and where conservation and management activities would be most effective. Population monitoring differs from WNS surveillance in that it concerns the status of entire species or genetically important populations, rather than the distribution and dynamics of the disease.

Until the threat of WNS has passed or has been mitigated, best practices are needed for the maintenance and recovery of bat populations of greatest conservation concern.

G.2. Goals and Action Items

Goal 1: Develop and validate rapid-assessment monitoring plans to determine differences in susceptibility among species, and identify which species are most vulnerable to extinction due to WNS.

Actions:

- (1) Seek expert consensus on monitoring techniques and protocols that will accurately gauge impacts of WNS on bat species relative to feasibility of implementation.
- (2) Develop and implement monitoring plans to establish the degree to which different species of bats are susceptible to WNS.
- (3) Establish best practices for context-specific WNS population monitoring and implement those protocols on a range-wide basis for species of greatest conservation concern.

Goal 2: Establish criteria for prioritizing conservation activities

Actions:

- (1) Develop criteria, incorporating input from human dimensions enquiry, for determining which species affected by WNS warrant conservation action that may include identifying relative proportions of populations affected or thresholds of population size at which conservation actions should be taken.
- (2) Develop contingency plans for rapidly shifting focus of conservation actions if populations of greatest conservation concern are declining and nearing the threshold of population viability, e.g., extirpation or extinction.

Goal 3: Determine best practices for maintaining and recovering populations

Actions:

- (1) Develop techniques and protocols for assessing and mitigating the population effects of WNS.
- (2) Prioritize monitoring and recovery efforts based on analysis of species susceptibility (E.2., Goal 3).
- (3) Determine the feasibility and role for captive propagation for species of conservation concern.
- (4) Protect or restore summer and winter habitat to ensure quality habitat is available for WNS-affected bat populations.
- (5) Should proven environmental treatments for WNS become available, establish methods for restoring hibernation sites to provide refuge for surviving and non-affected individuals.
- (6) Determine whether previously occupied hibernacula and suitable but previously unused sites warrant continued protection and clearly identify a means of justifying such protection in the absence of bat occupancy.
- (7) Mitigate anthropogenic sources of mortality that have additional detrimental influences on bat populations.

Goal 4: Research most effective methods for monitoring, conserving, and recovering affected populations.

Actions:

- (1) Establish and maintain a list of prioritized research needs and work closely with the research working group to see that high-priority needs are communicated and/or addressed.
- (2) Regularly assess monitoring, conservation, and recovery practices in light of new research findings, and refine when appropriate.